PROCESS FOR PRODUCTION OF CELLULAR THERMOPLASTIC BODIES

This is a continuation-in-part of my earlier application Ser. No. 505,274, filed Sept. 12, 1974 and now abandoned.

The present invention relates to the production of expanded thermoplastic articles and, more particularly, to a process for the production of such articles.

It has long been known in the extrusion and molding process art to form expanded thermoplastic articles, having fine cells distributed therein, by the general introduction or injection of a gas into the thermoplastic material after it has been rendered molten in the extruder. An example of such a process is disclosed in U.S. Pat. No. 2,928,130 to Gray wherein the gas is injected between stages into a two-stage screw extruder where it is solubilized in the thermoplastic melt and thoroughly admixed in it prior to discharge of the thermoplastic melt containing the solubilized gas from the extruder.

Other variations of this process are also known to the art which is presently keenly aware of the thermoplastic materials which may be employed, the expanding or blowing gases which may be employed and the nucleating agents and other addition agents which may be further advantageously employed in the practice of such process for the production of cellular thermoplastic bodies.

From the standpoint of the resultant article produced by such processes for the production of cellular thermoplastic bodies, it is to be noted that the process may be utilized to produce either a continuous two-dimensional (constant cross-sectional) body of the type produced in the extrusion of wire and cable insulation or in the production of three-dimensional bodies on a non-continuous basis such as in the production of a series of bodies in a mold.

Generally, gas injection in an extrusion process may advantageously be employed in conjunction with molding processes, such as vacuum molding and injection molding processes. In the case of the latter, the mixture of molten thermoplastic material and gaseous blowing agent is fed to an accumulation zone where a measured volume of the molten thermoplastic material and gaseous blowing agent mixture is collected prior to injection into a mold. Such a process is disclosed in U.S. Pat. No. 3,268,636 to Angell.

As employed herein, the term "mixture of molten thermoplastic material and gaseous blowing agent" is understood to mean either a random or uniform distribution of the gaseous blowing agent within the molten thermoplastic matrix and to include solutions as well as non-homogeneous physical mixtures of the gaseous blowing agent in the molten thermoplastic material matrix.

Difficulty has been encountered in the use of prior thermoplastic polymer extrusion processes for the production of cellular thermoplastic bodies employing the gase injection of an expanding or blowing agent into the molten thermoplastic material in an extruder. Such difficulties are associated with variations in physical properties of the resultant thermoplastic bodies produced by the process due to pressure variations within the extruder which, in turn, cause variations in the volume of the gaseous expanding or blowing agent injected into the molten thermoplastic material. Such pressure variations can be caused by changes in a wide

variety of processing variables encountered in extrusion and which are well known to those skilled in the art.

Accordingly, it is the prime object of the present invention to provide an improved process for the production of cellular thermoplastic bodies having substantially uniform physical properties.

It is a further object of the present invention to provide an improved process for the production of cellular thermoplastic bodies wherein substantially uniform volumes of expanding or blowing gas are injected into the thermoplastic material in the extruder.

Other aims and advantages will be apparent from the following description and appended claims.

In accordance with the present invention, a process is provided for the production of a cellular thermoplastic body, wherein solid thermoplastic material is melted under pressure in an extruder, a gaseous blowing agent is injected into the molten thermoplastic material under pressure and said molten thermoplastic material and said gaseous blowing agent is passed to a zone of reduced pressure to effect the cellular expansion of said thermoplastic material by said gaseous blowing agent, and wherein said gaseous blowing agent is metered at sonic velocity at a point upstream of the injection of said gaseous blowing agent into said molten thermoplastic material.

It is to be noted that the following equation sets forth the relationship for determining the critical pressure in the throat of constricting metering nozzle employed in accordance with the present invention:

$$P_c = P_1 \left(\frac{2}{k+1}\right)^{\frac{k}{k-1}} \qquad \text{Eq. I}$$

where

P_c = pressure in nozzle throat

P_1 = upstream (regulated) pressure

$$k = \frac{C_p}{C_v}$$

where C_p, C_v = specific heats at a constant pressure and volume, respectively.

Accordingly, under these conditions, high pressure, constant velocity metering is carried out such that the gas flow (W) in standard cubic feet per hour passing through the metering nozzle is a function only of the upstream pressure (P_1) and the area (a) of the nozzle (orifice), as represented by the following formula:

$$\text{Eq. II: } W(\text{ft.}^3/\text{hr.}) = f(P_1, a)$$

Accordingly, it may be seen that, when the blowing gas inlet feed line to the extruder is metered to provide a blowing agent velocity of sonic velocity, the gas flow rate is insensitive to pressure changes at the downstream side of the metering point. Therefore, pressure fluctuations downstream of the metering point and, consequently, within the extruder, will not result in changing the volume of gas injected into the molten thermoplastic stream and will provide uniformity of gas injection and uniformity of porosity in the resultant product.

It has also been found in both profile extrusion (constant cross-sectional extrusion) and three-dimensional